LIFE HABITS AND DISTRIBUTION OF RIVERINE *LAMPSILIS RADIATA LUTEOLA* (MOLLUSCA: BIVALVIA)

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Abstract

Lampsilis radiata luteola is an abundant, widely distributed, freshwater bivalve whose autecology and habitat preferences are little known. Analysis of populations from an Ohio stream reveal that it is most frequently found on compositionally mixed substrata, near shore, where current velocities are low. Although the life position of *L. r. luteola* is extremely variable, the most common orientation observed was with the shell approximately two-thirds buried in the substratum, the anteroposterior axis at a 45° angle to the substratum, and the siphonal areas normal to the direction of eurrent flow. While *L. r. luteola* is an active burrower and crawler, its punctuated and variable mode of locomotion is in contrast to the more constant and predictable life habits of many comparably sized marine bivalves.

Biometrical studies show that stream-dwelling *L. r. luteola* are larger than lake-dwelling forms. Also, the relation of shell length to age is nearly linear for individuals three to eight years old. The paucity of bivalves less than three years old indicates the *L. r. luteola* experiences sporadic recruitment and frequent reproductive failures.

Introduction

Lampsilis radiata luteola (Lamarck, 1819) (Unionidae) is one of the most widely distributed freshwater bivalves in North America. It occurs throughout the Mississippi and Missouri river systems, much of Canada east of the Rocky Mountains, the St. Lawrence drainage, and the Atlantic slope south to South Carolina. In addition, *L. r. luteola* is extremely widely distributed in aquatic environments within its geographic range. It is found in streams, ponds, lakes, and other wetland areas on substrata ranging from muds to gravel. Moreover, *L. r. luteola* is frequently the most abundant bivalve in these environments (Burch 1973; Clarke 1973) and is a dominant organism in terms of standing crop and biomass. For example, unionid bivalves have the largest standing crop (82.5 g/m^2 wet) and individual biomass (average individual wet weight is about 10.5 g) of any invertebrate group in western Lake Erie, and *L. radiata* is the most abundant unionid (Wood 1953).

It is therefore surprising that very little ecological information has been published concerning this remarkable species. The literature concerning lentic populations mainly focuses on behavioral characteristics and biogenic modification of sediments (e.g., McCall et. al. 1979; McCall and Tevesz 1982). And with the exception of communications by Whittine (1969) and Salmon and Green (1983) there is very little published information on the ecology and distribution of *L. radiata* in lotic environments.

This paper is an attempt to begin building a body of knowledge concerning the autecology and distribution of lotic populations of *L. r. luteola.* In this paper, we provide new information on the distribution, biometrics, age, substratum preference, and life habits of *L. r. luteola.* The Vermilion River, Ohio, was chosen as the study area because it is a relatively clean, accessible river, which, like many others, contains large populations of *Lampsilis.*

The Vermilion River is 58.7 mi in length, has an average fall of 7.8 ft/mi, and drains an area of 271.7 sq mi (Ohio Division of Water 1954: Fig. 1). The river flows through mostly rural countryside, where its chief pollutants are silt and fertilizers from farms. The presence of a variety of pollution-intolerant organisms (e.g., stonefly and mayfly nymphs; caddis fly larvae) in the river over much of its length indicates that the river is mostly reasonably clean (Beck 1954; Gaufin and Tarzwell 1952, 1956).

Methods

Live and freshly dead *L. r. luteola* and associated Unionidae were collected in summer months during 1975–82 at thirteen stations along the Vermilion River by bank-combing and wading (Fig. 1; Stas. 1–7, 9–14). The general characteristics of the substratum were recorded for each station. In addition, four more stations (Fig. 1; Stas. 8, 15–17) were sampled in detail by wading and

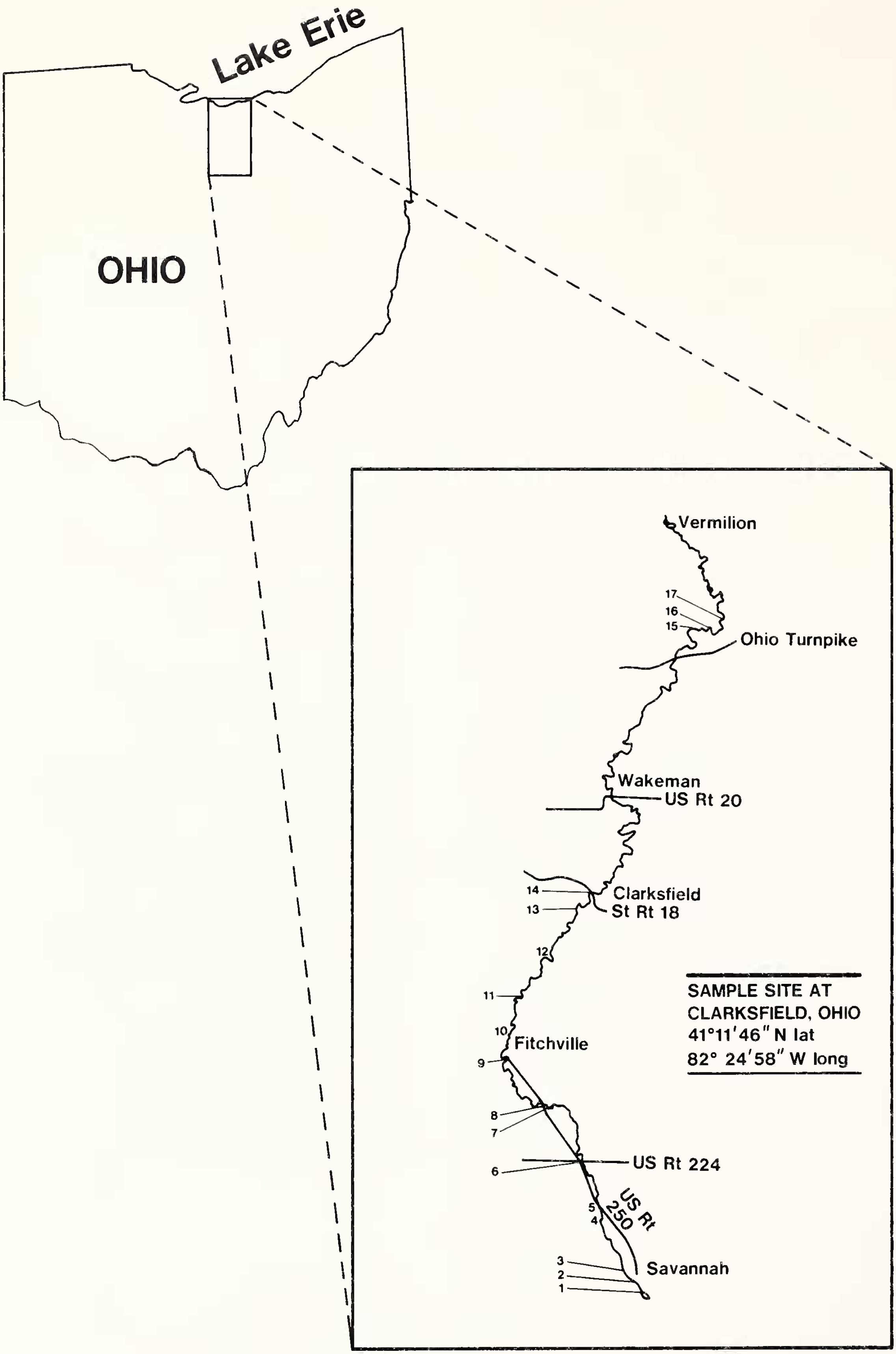

Fig. 1. Vermilion River. Scale (inset): 1 in. = 5 mi.

Key to Figure 1
COLLECTING STATIONS

1. Location: Mud Lake. At the intersection of U.S. Rt. 250 and U.S. Rt. 224, turn SE and travel 6.2 mi to the first right turn after Crum Rd., then due E 0.1 mi; Ashland Co., Oh.
2. From the intersection of U.S. Rt. 250 and Crum Rd., go W on Crum 0.5 mi to St. Rt. 545. Turn right onto 545 heading to an overpass 0.4 mi NE; Ashland Co., Oh.
3. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 250 SE for 5.0 mi to Clear Creek Rd. in Savannah, Oh. Go W on Clear Creek Rd. 0.8 mi to an overpass; Ashland Co., Oh.
4. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 250 SE 3.0 mi to Base Line Rd. Take Base Line Rd. W 0.5 mi to a steel truss span bridge; Ashland Co., Oh.
5. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 250 SE 2.1 mi to river overpass; Ashland Co., Oh.
6. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 224 E 0.1 mi to river overpass; Ashland Co., Oh.
7. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 250 NW 3.0 mi to Town Line Rd., then E on Town Line Rd. to a curve which parallels the river bed below, then hike 0.1 mi up river; Ashland Co., Oh.
8. From the intersection of U.S. Rt. 250 and U.S. Rt. 224, take U.S. Rt. 250 NW 2.8 mi to steel truss span bridge, then upstream 0.1 mi from bridge; Huron Co., Oh.
9. From the intersection of U.S. Rt. 250 and Fitchville River Rd., take U.S. Rt. 250 E 0.1 mi to bridge, and from there to 200 m upstream; Huron County, Ohio.
10. From the intersection of U.S. Rt. 250 and Fitchville River Rd., take Fitchville River Rd. N 1.1 mi to Fayette Rd. Then take Fayette Rd. E 0.6 mi to a steel truss span bridge just W of Palmer Rd; Huron Co., Oh.
11. From the intersection of U.S. Rt. 250 and Fitchville River Rd., take Fitchville River Rd. 5.3 mi N to Prospect Rd. Then take Prospect Rd. E 0.5 mi to steel truss span bridge; Huron Co., Oh.
12. From the intersection of U.S. Rt. 250 and Fitchville River Rd., take Fitchville River Rd. 8.2 mi N to Cook Rd. Take Cook Rd. SE 0.4 mi to a steel arch-truss span bridge; Huron Co., Oh.
13. From the intersection of Fitchville River Rd. and Cook Rd., take Fitchville River Rd. 1.1 mi N to Zenobia Rd., then take Zenobia Rd. E 0.1 mi and turn S (right), following this road around a curve to a steel span bridge; Huron Co., Oh.
14. From the intersection of Fitchville River Rd. and Zenobia Rd., take Zenobia Rd. 0.7 mi E to a bridge; Huron Co., Oh.
15. From the intersection of St. Rt. 60 and St. Rt. 116 in Birmingham, Oh., take St. Rt. 116 E 1.3 mi to Gore Orphanage Rd. Then take Gore Orphanage Rd. N 1.8 mi to bridge; Lorain Co., Oh.
16. From the intersection of St. Rt. 60 and St. Rt. 116, take St. Rt. 116 E 1.3 mi to Gore Orphanage Rd., then take Gore Orphanage Rd. N 2.4 mi to Morse Rd. Follow Morse Rd. to Bank Rd., then take Bank Rd. S 0.9 mi until it ends. From the dead end, hike due SW circa 0.5 mi to river; Lorain Co., Oh.
17. From the S end of Bank Rd., hike 0.8 mi NE to river; Lorain Co., Oh.

SCUBA for live individuals only, and the following information was recorded where each individual was found: substratum type (estimated as gravel, sand, or mud, or some combination of these); distance from shore; current velocity (measured with a submerged float and stopwatch); inclination of the anteroposterior axis of the bivalve with respect to the substratum surface (estimated as either 0, $>0<45°$, 45°, $>45°<90°$, or 90°); orientation of posterior with respect to direction of current (measured with protractor); and fraction of shell buried in substratum (estimated as ≥ 0.15, 0.25, 0.33, 0.50, 0.67, or ≥ 0.75).

Over 130 live *L. r. luteola* were collected and the following data were taken in the laboratory: total length (greatest linear dimension parallel the hinge); anterior length (portion of total length anterior of the mid-point of the umbo); height (greatest linear dimension normal to length and in the same plane); and width (greatest linear dimension across both valves normal to length and width). Absolute age determinations were made by cutting a valve in two with a rock saw, polishing one of the sections, and counting the annual markings under a microscope. Taxonomic identifications were provided by Dr. David H. Stansbery, the Zoology Museum, Ohio State University, Columbus, Ohio.

Distribution

Areal

The presence or absence, at 17 sampling stations, of *L. r. luteola* and associated Unionidae, is represented in Table 1 (see also Fig. 1). The predominant substratum

TABLE 1
Occurrence of *Lampsilis radiata luteola* at 17 sampling stations

		Sampled Bivalves							
Station No.	Predominant Substratum Type	*Lampsilis radiata luteola (Lamarck, 1819)*	*Lampsilis ventricosa (Barnes, 1823)*	*Anodonta grandis grandis (Say, 1829)*	*Strophitus undulatus undulatus (Say, 1817)*	*Lasmigona costata (Rafinesque, 1820)*	*Fusconaia flava (Rafinesque, 1820)*	*Elliptio dilitata (Rafinesque, 1820)*	*Anodontoides ferussacianus (Lea, 1934)*
1	mud			X*					
2	mud/sand			X*					
3	sand/mud	X		X*					
4	mud/sand/gravel			X*					
5	mud			X*					
6	gravel	X*							X
7	sand/mud, with gravel	X	X			X*	X		X
8	gravel, with pockets of sand/mud	X*	X			X		X	
9	bedrock/gravel	X*				X	X		
10	gravel	X*				X		X	
11	gravel	X*	X		X		X	X	X
12	gravel	X*						X	
13	sand/gravel	X*	X			X	X	X	
14	bedrock/gravel	X*				X	X	X	
15	gravel, with pockets of sand/mud	X*	X			X			
16	gravel, with pockets of sand/mud	X*	X			X			
17	gravel, with pockets of sand/mud	X*	X		X	X			

*Indicates most abundant species at particular site.

type found at each station is also listed there. The table and figure demonstrate that *Anodonta grandis grandis* is the numerically dominant unionid at the sampling stations in Mud Lake and at the source area of the river. But below Station 5 the numerically dominant species at the collecting locales is generally *L. r. luteola*, although *Lasmigona costata* is the most abundant species at Station 7. Additionally, Table 1 reveals correlations between lacustrine-conditions/muddy-substrata and the presence of a relatively species-poor fauna dominated by *A. g. grandis* (one to two species). Typical fluvial conditions and coarser substrata, on the other hand, appear to be associated with a relatively species-rich fauna (two to six species) generally dominated by *L. r. luteola*. Also correlated with this downstream increase in species richness is an increase in substratum heterogeneity.

The fact that we have yet to discover *Lampsilis* living on soupy muds in the Vermilion River is interesting, because it occurs with *A. g. grandis* on similar bottoms in Lake Erie (McCall et al. 1979; Tevesz and McCall 1979). This difference in distribution may be related to the smaller size and thinner shells of lake-dwelling forms (cf. Clarke 1973; Harman 1970) which would make them less prone to sinking into the substratum.

Within-Habitat

Table 2 provides more detailed information on the substratum distribution of *L. r. luteola* and the five unionid species (combined) collected live at Stations 8, 15, 16, and 17. Of three "pure" substratum categories, *L. r. luteola* was most abundant on sand, compared to mud or gravel, was most frequently found on substrata containing a mixture of particle sizes, and was particularly common on a mud/sand mix and a mud/sand/gravel mix. The pattern of substratum preference also obtains for the remainder of the Unionidae observed at these stations.

Information on the distance from shore and associated current velocities of all live-collected Unionidae at Stations 8, 15, 16, and 17 is presented in Tables 3 and 4. Over 60% of *L. r. luteola* and other Unionidae are found within 1 m of stream bank as shown in Table 3. Over 75% of the live-collected Unionidae, including *L. r. luteola*, were found where current velocities were less than 5 cm/sec

TABLE 2
Substratum Distribution (%)

	Mud	*Sand*	*Gravel*	*M/S*	*G/S*	*M/S/G*	
Lampsilis radiata luteola	0	16	3	32	15	34	n = 134
Other Unionidae[1]	0	18	15	25	13	29	n = 55

[1] *Lampsilis ventricosa; Elliptio dilitata; Lasmigona costata; Strophitus undulatus undulatus; Anodontoides ferussacianus.*

TABLE 3
Distance from Shore

Distance from shore (m)	*Lampsilis radiata luteola (%) n = 136*	*Other Unionidae (%) n = 52*
1	61.8	61.5
2	14.7	21.2
3	8.8	7.7
4	7.4	5.8
5	6.6	3.8
6	0.7	0.0

TABLE 4
Current Velocity Preference

Current Velocity (cm/sec)	*Lampsilis radiata luteola (%) (n = 136)*	*Other Unionidae (%) (n = 52)*
≤5	77.9	75.0
>5 but ≤10	13.2	11.5
>10 but ≤15	2.2	3.8
>15 but ≤20	0.0	3.8
>20 but ≤25	0.0	0.0
>25 but ≤30	6.6	5.8

(Table 4). Thus, *L. r. luteola* appears to show definite preferences for certain microhabitats within the river at the sampling sites. It was most frequently found on compositionally mixed substrata near shore, where current velocities are low. The same statement is true for the other live-collected Unionidae as a group. The within-habitat distribution of all these live-collected Unionidae at the sampling stations is highly similar.

Life Position and Locomotion

Table 5 presents information on the life position of *L. r. luteola* collected in situ. While life position of *L. r. luteola* is extremely variable, the most common orientation recorded was with the shell approximately two-thirds buried in the substratum, the anteroposterior axis at a 45° angle to the substratum, and the siphonal areas normal to the direction of current flow.

The life position and locomotory behavior of *L. r. luteola* from the Vermilion River and adjoining areas of Lake Erie were also observed in laboratory microcosms containing simulated native substrata and regulated to ambient temperature. The burrowing sequence of *L. r. luteola* observed for this laboratory study from both stream and lake population is similar, and is described by McCall et al. (1979). Individuals from both the stream and lake are active semi-infaunal crawlers.

TABLE 5
Life Position of *L. r. luteola*

Orientation of posterior (siphonal) area with respect to current (% of population). 0° → area oriented directly into current.

0°	45°	90°	135°	180°	n = 133
23	14	40	11	13	

Orientation of anteroposterior axis with respect to substratum (% of population).

0°	>0° < 45°	45°	>45° < 90°	90°	n = 136
9	18	29	20	24	

Fraction of shell embedded in substratum (% of population). n = 136

≤.15	.25	.33	.50	.67	≥.75
8	5	18	10	51	8

Burrowing rate indices (BRI's) (Stanley 1970) for *L. r. luteola* are presented in Table 6. These data show that the BRI of *L. r. luteola* is variable, but by comparison to marine bivalves of roughly similar size and shape, *Lampsilis*, over all, is a slow burrower (cf. Stanley 1970). In addition, the burrowing rate is dependent on the type of substratum the clams inhabit. The rates on fine substrata are two to four times higher than rates on coarse substrata. This relation of BRI to substratum type is otherwise unreported for freshwater bivalves.

The burrowing and crawling behavior of *L. r. luteola* was frequently interrupted by long periods of stasis. Usually there was a lag time of several minutes to several days before animals placed in the laboratory microcosms began locomotory behavior. The time involved to complete a burrowing sequence also took several minutes to several days, depending on the number of pauses, and duration and number of interspersed semi-infaunal crawling episodes. This punctuated and variable mode of behavior is in contrast to the more constant and predictable habits of many shallow-water marine bivalves of comparable size studied by Stanley (1970). Comparable information for other freshwater species is scarce.

The meager burrowing ability of *Lampsilis*, coupled

TABLE 6
Burrowing Rate Indices

$$\left(\frac{\sqrt[3]{\text{mass (g)}}}{\text{burrowing time (sec.)}}\right) \times 100$$

Substratum	*Bivalve 1 (Length = 56.1 mm)*	*Bivalve 2 (L = 69.8 mm)*	*Bivalve 3 (L = 62.4 mm)*	*Bivalve 4 (L = 92.9 mm)*
mud	0.13; 0.13			
coarse sand	0.057	0.049; 0.057		
50% sand/50% gravel			0.031; 0.036; 0.062	
33% mud/67% sand				0.13

TABLE 7
Lampsilis radiata: Comparative Morphometrics

Source	*Sample Site*	*n*	*Mean Length ± S.E.*	*Mean Height ± S.E.*	*Mean Width ± S.E.*	*Mean Anterior Length ± S.E.*	*Mean H/L ± S.E.*	*Mean W/H ± S.E.*	*Mean Ortman Obesity ± S.E. (W/L)*	*Mean Age*
This study	Vermilion R. #8 (Ohio)	88	95.1 ± 1.1	54.6 ± 0.6	38.5 ± 0.6	32.7 ± 0.4	0.58 ± 0.002	0.70 ± 0.01	0.40 ± 0.004	5.9 yrs.
	Vermilion R. #15-17 (Ohio)	41	93.0 ± 2.4	51.8 ± 1.3	33.8 ± 1.1	33.1 ± 0.8	0.56 ± 0.005	0.65 ± 0.01	0.36 ± 0.006	4.9 yrs.
Cvancara and Freeman (1978) (*L. radiata*)	Lake Ashtabula	9	90.0 ± 8.4	53.0 ± 5.1	31.0 ± 3.5		0.60 ± 0.014	0.58 ± 0.026		
	Sheyenne River (N. Dakota)	252	91.0 ± 0.7	53.0 ± 0.4	31.0 ± 0.3		0.59 ± 0.002	0.59 ± 0.026		
Cvancara (1972) (= *L. r. siliquoidea*)	Long Lake (Minnesota)	1024	49.0 ± 0.2	32.0 ± 0.1	17.0 ± 0.1		0.65 ± 0.001	0.53 ± 0.001		
Brown, Clark and Gleissner (1938) (= *L. siliquoidea*)	East Harbor (Lake Erie)	131	87.3	47.8	35.5	22.5				
	Fish Hatchery Bay (Lake Erie)	84	66.9	37.0	28.7	16.1				
	Pelee Island (Lake Erie)	62	58.2	34.2	27.2	14.5				
Cvancara (1970) (= *L. siliquoidea*)	Red River Valley (N. Dakota and Minnesota)	253 [♂ only]	90.0				0.52	0.65		

with its preference for near-shore, shallow-water habitats associated with low-flow velocities, suggests that this bivalve is not frequently physically removed from the substratum by erosion. Further evidence of this is the absence of appreciable physical wear on almost all live-collected *L. r. luteola*, compared to the extensively abraded appearance of loose valves collected on the sediment surface. *L. r. luteola* does not selectively reduce the forces exerted on it by currents. In fact, the preferred orientation is normal to flow. This suggests that the organisms are passively oriented by flow much like a flat rock.

Biometrics

Morphometrical information for *L. r. luteola* from the Vermilion River and other environments is presented in Table 7. As shown here, *L. r. luteola* from the Vermilion River are morphometrically similar to other *Lampsilis radiata* riverine populations and those from artificial impoundments. Further, these riverine/impoundment populations tend to have larger average dimensions than those from naturally occurring lakes. These observations support the findings of several studies (cf. Clarke 1973; Harman 1970) who report that *L. r. luteola* and several other Unionidae are typically larger in streams than lakes.

Additionally, comparative figures on the upstream (Sta. 8) versus downstream (Stas. 15–17) populations of *L. r. luteola* support the findings of Ortmann (1920) in that they show this species does not follow the "Law of Stream Distribution." It should be noted, however, that the "Law of Stream Distribution" was mainly derived from study of large rivers in which habitat changes from shallow, rapid-flow environments to much deeper, slower -flow environments. The Vermilion is not such a river.

Age Structure

The age distribution of live-collected *L. r. luteola* is shown by the data in Table 8. Age data for all live-collected Unionidae are given in Table 9. The mean age of all live-collected *L. r. luteola* is 5.55 years, and few individuals less than three years of age were observed. It is possible but doubtful that small individuals were missed during this study, because the length of three-year-old individuals is only slightly less than 9 cm (Fig. 2) which is a size readily collectable by our techniques.

Individuals between three and eight years of age show a nearly linear relation of age to mean length, as shown in Figure 2. Younger and older individuals are much smaller than would be predicted by the curve in Fig. 2, which indicates that the clams grow most during their second year of life and grow much more slowly after reaching eight years of age. The absence of young individuals has been noted for *Elliptio complanata* in lacustrine environments (Fisher and Tevesz 1976; Matteson 1948).

TABLE 8
Age Distribution (%) of *Lampsilis radiata luteola*

Age (in years)	*Percent of Individuals (n = 133)*
1	1.5
2	1.5
3	9.8
4	15.0
5	25.6
6	21.1
7	11.3
8	12.0
9	1.5
10	0.8

TABLE 9
Mean Age of Live-Collected Individuals

Species	*Mean Age*	*Number of Individuals*
L. r. luteola	5.55	129
L. ventricosa	5.87	23
E. dilitata	5.90	11
L. costata	5.72	11
A. ferussacianus	5.20	5
S. undulatus	4.67	3

The observed age structure for *L. r. luteola* suggests that recruitment is not continuous. This could be due to a number of factors. Matteson (1948) noted that environmental stresses such as low dissolved oxygen and elevated temperatures can result in the death of both newly settled young and gravid females of *E. complanata*, as well as the expulsion of any maturing glochidia from gravid females. For *L. r. luteola*, males and females are present in approximately equal numbers; there does not appear to be evidence for differential mortality. It should also be noted that since *L. r. luteola* depend upon fish for the dispersal of their parasitic larvae, factors affecting the biology of the host organisms may be important in regulating the age structure of *L. r. luteola*. Detailed surveys covering a reasonably long period of time would be required to resolve this problem.

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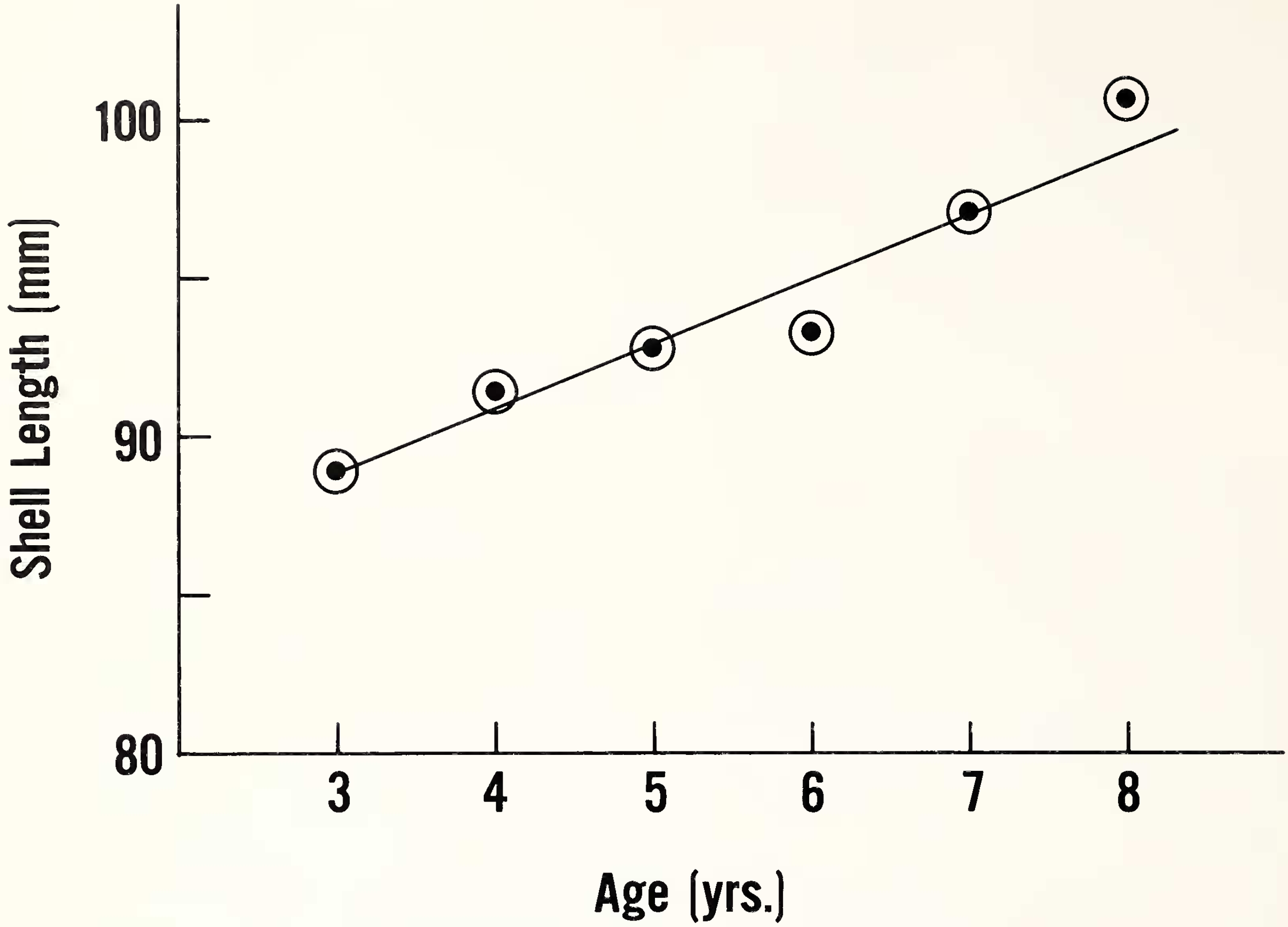

Fig. 2. Age/mean-length relationships for 3- to 8-year-old *L. r. luteola.*

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